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Use of Produced Water in Recirculating Cooling Systems at Power Generating Facilities

Deliverable Number 7
Implementation Requirements

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Disclaimer

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Abstract

The purpose of this study is to evaluate produced water as a supplemental source of water for the San Juan Generating Station (SJGS). This study incorporates elements that identify produced water volume and quality, infrastructure to deliver it to SJGS, treatment requirements to use it at the plant, delivery and treatment economics, etc.

SJGS, which is operated by Public Service of New Mexico (PNM) is located about 15 miles northwest of Farmington, New Mexico. It has four units with a total generating capacity of about 1,800 MW. The plant uses 22,400 acre-feet of water per year from the San Juan River with most of its demand resulting from cooling tower make-up. The plant is a zero liquid discharge facility and, as such, is well practiced in efficient water use and reuse.

For the past few years, New Mexico has been suffering from a severe drought. Climate researchers are predicting the return of very dry weather over the next 30 to 40 years. Concern over the drought has spurred interest in evaluating the use of otherwise unusable saline waters.

PNM is evaluating the development of the produced water project in two phases. The first phase would consist of a pipeline to convey water from Close-in producers to a new water treating facility located at SJGS. In Phase 2, the Collection Center in Bloomfield would be built and the pipeline would be extended to its full length. Burlington Resources would install satellite collection stations and tie/extend the Hart Canyon Line and the CO_2 Gas Line to the Collection Center. The produced water treatment system at SJGS would be expanded to handle the additional flow.

Legislation enacted in 2004 removed regulatory barriers that would have required beneficial use assessments for each source of produced water. Produced water can now be disposed of (via treatment and use) at electric generating stations in New Mexico for treatment and reuse.

There are a number of regulatory agencies that must be engaged and permits that must be obtained to build and operate the produced water gathering, conveyance and treatments system. Project components that must be addressed by PNM are the pipeline, the treatment plant at SJGS and the Collection Center in Bloomfield.

Table of Contents

Figures

Tables

Executive Summary

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PNM is evaluating the development of the produced water project in two phases to spread capital expenditure over a period of 3 to 5 years. The total recovered water after treatment would be 534 AF/yr for Phase 1 and 1,700 AF/yr for Phases 1 and 2.

Phase 1 would consist of the following elements:

- 10.8-mile pipeline to gather and convey water from CBM producers in the Kirtland area, BHP Billiton (mine water) and Prax Air (cooling tower blowdown)
- Produced water receiving, storage and transfer equipment
- HERO® system to treat gathered produced water and SO_2 absorber Purge Water for reuse at SJGS
- 10-acre evaporation pond to handle excess wastewater generated in the Phase 1 portion of the project.

Phase 2 would consist of the following elements:

- Satellite collection stations (BR's scope of work) to gather water north of Aztec via their Hart Canyon Line and CO_2 Gas Line
- Collection Center in Bloomfield and pretreatment of water to remove oil and grit
- Pipeline from the Kirtland area to Bloomfield for a total length of 28.5 miles
- Expand the HERO® system by adding additional media filter, WAC and RO capacity
- Refurbish BC 3 to treat the increased wastewater flow from the HERO® system.

As a result of a bill signed into law March 2004, SJGS could treat and utilize produced water for cooling tower make-up, scrubber make-up, ash wetting, etc. The jurisdiction of produced water the Oil Conservation Division (OCD) of New Mexico would end at the treatment system at SJGS. Air and wastewater emissions from the treatment plant would be regulated by the New Mexico Environment Department (NMED).

In Phase 1, an EA must be conducted to determine if any impacts would be created by building and operating the initial portion of pipeline. The Bureau of Land Management (BLM) would likely be the lead agency in this effort because a significant portion of the pipeline passes over federal lands. OCD would review the pipeline design, require integrity testing before start-up, and require operating and spill contingency plans.

The produced water treatment plant at SJGS would be treated like a storage/disposal facility by OCD and a permit would have to be obtained to build and operate it. In Phase 1, BTEX emissions would be low, because Phase 1 water would be produced entirely from CBM. NMED would be notified of the emissions at the outset of the project; however, a modification to the plant air permit is not likely. The plant wastewater permit would have to be modified to account for HERO® system reject. Phase 1 environmental permit activity could take up to six months to complete.

In Phase 2, an EA would be conducted to determine if any environmental impacts would be created by completing the pipeline. BLM could be the lead agency; however, this leg of the pipeline passes over much more private property and city and state lands than the Phase 1 leg. OCD would review the pipeline completion design, require integrity testing of the extension before start-up and require updates to the operating and spill contingency plans.

The Collection Center in Bloomfield would be treated like a storage/disposal facility by OCD and a permit would be obtained to build and operate the center. An air permit would have to be obtained from NMED for potential BTEX emissions, which could range up to 14 to 56 pounds per day. No wastewater would be generated at the Collection Center.

The permit for the produced water treatment plant would be modified to reflect its increased capacity (OCD lead). Both air and wastewater permits would have to be modified to include emissions from produced water treatment (NMED lead). BTEX might also meet the threshold requirement to require reporting in the annual Toxics Reporting Inventory (TRI) for SJGS. Phase 2 environmental permit activity could take six to nine months to complete.

By developing the project in two phases, PNM could spread capital investment over a period of 3 to 5 years. The 10-acre evaporation pond and additional Phase 1 contingency would increase the total cost of the project by $3,010,000.

By developing the project in two phases, PNM could spread capital investment over a period of 3 to 5 years. Phasing the project would require a 10-acre evaporation pond to handle excess wastewater in Phase 1. PNM also has decided to use 25 percent contingency for the first phase of the project to cover uncertainties that might arise in a novel reuse project. The evaporation pond and additional contingency would increase the total cost of the project by $3,010,000 – from $37,870,000 to $40,880,000.

7.1 Introduction

Public Service of New Mexico (PNM) is evaluating the development of the produced water project in two phases. The first phase would consist of a pipeline to convey water from Close-in producers to a new water treating facility located at San Juan Generating Station (SJGS).[1] In Phase 2, the Collection Center in Bloomfield would be built and the pipeline would be extended to its full length. Burlington Resources (BR) would install satellite collection stations and tie/extend the Hart Canyon Line and the CO_2 Gas Line to the Collection Center. The produced water treatment system at SJGS would be expanded to handle the additional flow.

Legislation enacted in early 2004 removed regulatory barriers that would have required beneficial use assessments for each source of produced water. Produced water can now be disposed of at electric generating stations in New Mexico for treatment and reuse.

There are a number of regulatory agencies that must be engaged and permits that must be obtained to build and operate the produced water gathering, conveyance and treatments system. Project components that must be addressed by PNM are the pipeline, the treatment plant at SJGS and the Collection Center in Bloomfield.

7.2 Two-Phased Implementation Approach

PNM is evaluating the development of the produced water project in two phases to spread capital expenditure over a period of 3 to 5 years. Refer to Figures 7.1 and 7.2 for an overview of the Study Area and a schematic of both phases.

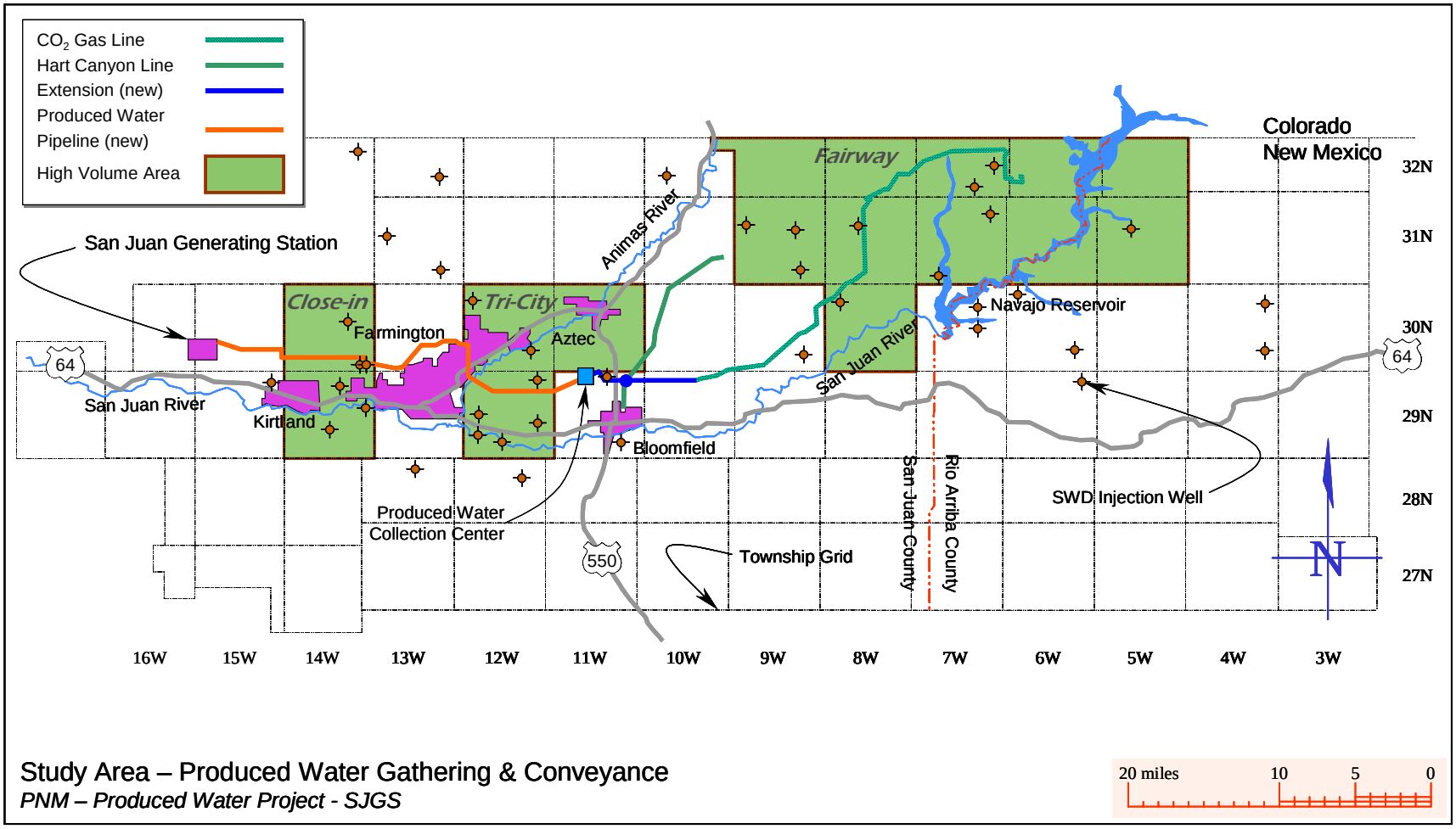
Phase 1 would consist of the following elements:

- Build the first leg of the pipeline (10.8 miles) to convey Close-in produced water to SJGS
- Connect coal bed methane (CBM) producers in the Kirtland area to the pipeline
- Collect mine water from BHP Billiton and cooling tower blowdown from Prax Air
- Install produced water receiving, storage and transfer equipment at SJGS
- Install the HERO® system to treat gathered produced water and absorber Purge Water for reuse at SJGS
- Install a 10-acre evaporation pond to handle excess wastewater generated in the Phase 1 portion of the project.

The total recovered water after treatment for Phase 1 would be 534 AF/yr.

[1] Refer to Deliverable 2, Infrastructure Availability and Transportation Analysis, for a description of produced water gathering and conveyance. Refer to Deliverable 3, Treatment and Disposal Analysis, for a description of the produced water treatment system – Alternative 10 – HERO® + BC 3.

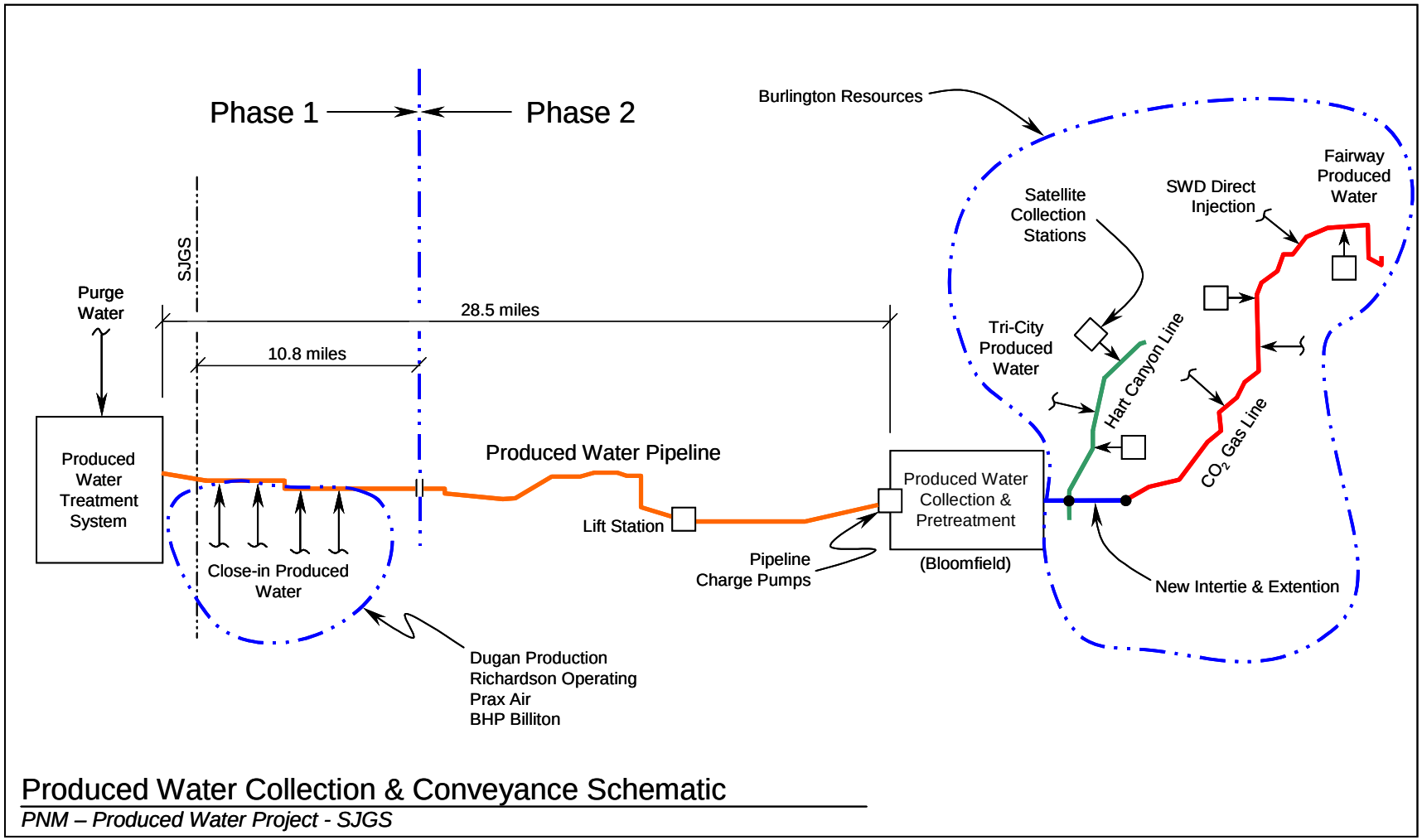
Figure 7.1



Study Area – Produced Water Gathering & Conveyance

PNM – Produced Water Project - SJGS

Figure 7.2


Phase 1
Phase 2
Burlington Resources
SJGS
Purge Water
28.5 miles
10.8 miles
Satellite Collection Stations
SWD Direct Injection
Fairway Produced Water
Tri-City Produced Water
Hart Canyon Line
CO_2 Gas Line
Produced Water Treatment System
Produced Water Pipeline
Lift Station
Produced Water Collection & Pretreatment
(Bloomfield)
Pipeline Charge Pumps
Close-in Produced Water
New Intertie & Extention
Dugan Production
Richardson Operating
Prax Air
BHP Billiton
Produced Water Collection & Conveyance Schematic
PNM – Produced Water Project - SJGS

Phase 2

- Install satellite collection stations (BR's scope of work) to gather water North of Aztec via their Hart Canyon Line and CO_2 Gas Line
- Build the Collection Center in Bloomfield and pretreat water to remove oil and grit
- Extend the pipeline from the Kirtland area to Bloomfield to a total length of 28.5 miles
- Expand the HERO® system by adding additional media filter, WAC and RO capacity
- Refurbish BC 3 to treat the increased wastewater flow from the HERO® system.

The average life-of-project recovered water after treatment for Phases 1 and 2 would be 1,700 AF/yr.[2]

7.3 Regulatory Barriers

The Oil Conservation Division (OCD) regulates all oil and gas production in New Mexico, and as such, produced water is designated a waste byproduct of production. There have been several attempts to utilize produced water (e.g. for dust suppression or road construction) rather than dispose of it via injection. In New Mexico, this action is defined as a beneficial use of the state waters and is regulated by the Office of the State Engineer (OSE). Under this designation, a right to use the water must be obtained and its use must comply with all applicable environmental regulations. The regulatory and environmental protection afforded by the OCD (designating the water as a byproduct of oil and gas production) would be lost with beneficial use.

PNM endeavored to address this regulatory issue by supporting a bill in the New Mexico legislature in January of 2004 that would specifically allow the "disposal" of produced water at electric generating facilities. This would allow produced water reuse as an alternate method of disposal. Therefore, a beneficial use would not be created and the regulatory jurisdiction of the OSE would not be invoked.

The bill was introduced into the January-February 2004 state legislative session and was signed into law March 2004 with the support of both the OCD and OSE. As a result, SJGS could treat and utilize the water for cooling tower make-up, scrubber make-up, ash wetting, etc. Most of the water would be consumed through evaporative losses or waters of moisture in scrubber sludge or ash. Any residual produced water (wastes from treatment) would require disposal to the evaporation ponds at SJGS.[3] OCD jurisdiction of produced water would end at SJGS and would include the treatment system. However, air and wastewater emissions from the treatment plant would be regulated by the New Mexico Environment Department (NMED).

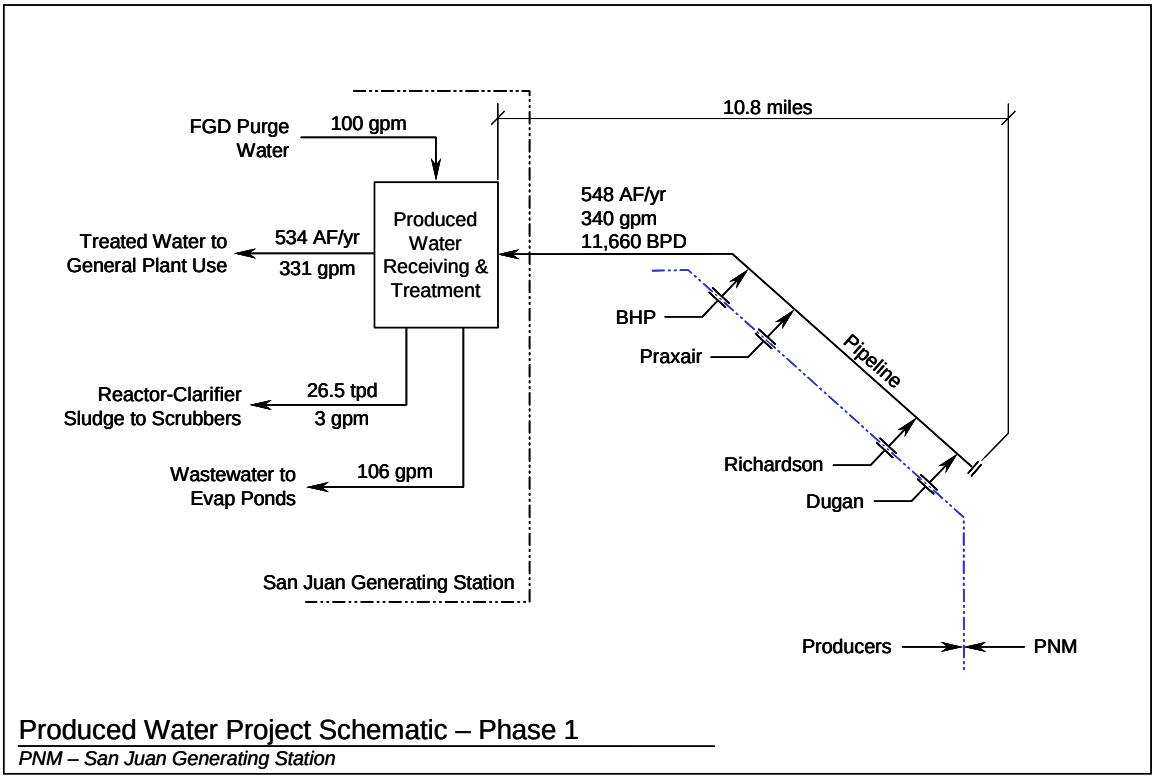
[2] The Phase 2 HERO®/BC 3 treatment system would recover 95.3 percent of incoming produced water and Purge Water.

[3] SJGS would have to obtain an amendment to their existing wastewater disposal permit for this new waste stream.

7.4 Phase 1 Implementation

The first phase of the produced water project would consist of the installation of a 14-inch diameter, 10.8-mile pipeline to convey water from Close-in producers in the Kirtland area to SJGS. Refer to Figure 7.3 for a process schematic of Phase 1 and to Figure 7.4 for an overview of Phase 1 and 2 treatment equipment. The pipeline would be the first leg of the 28.5-mile pipeline that would originate in Bloomfield at the Collection Center.

Figure 7.3



Produced Water Project Schematic – Phase 1

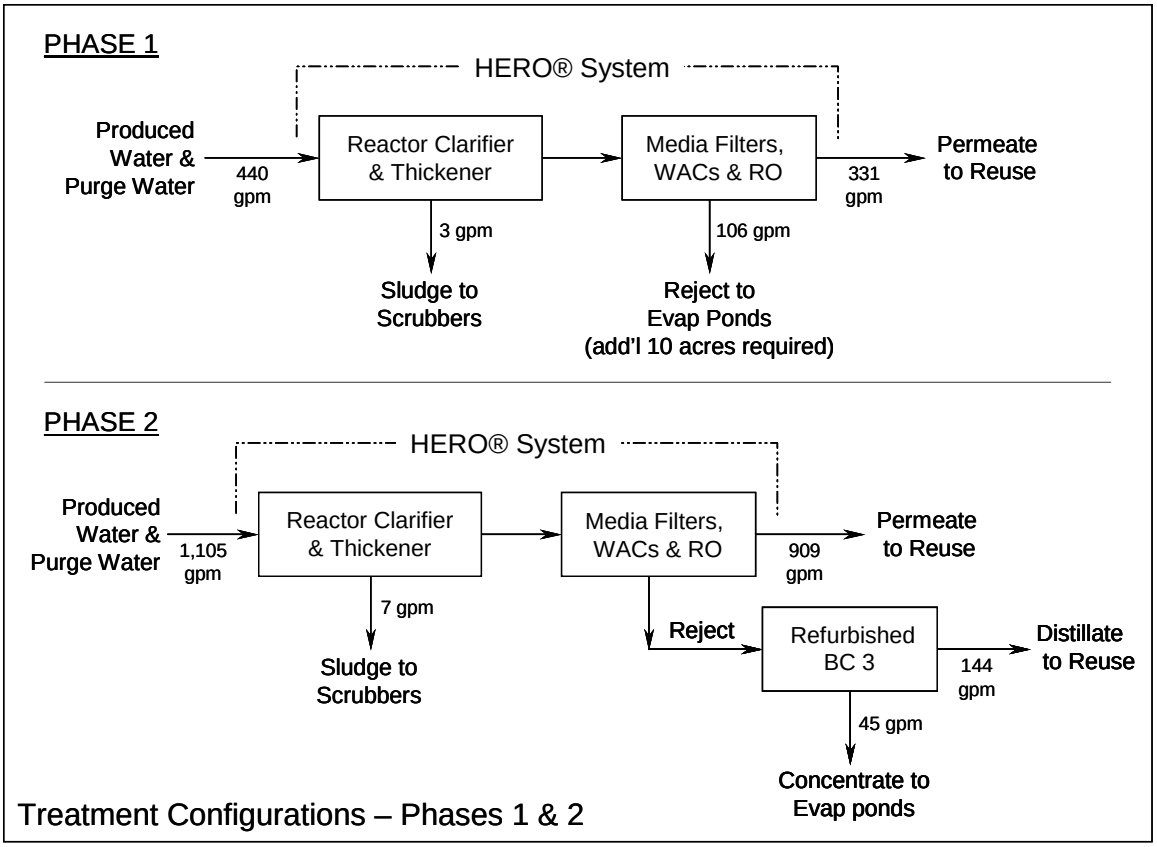
PNM – San Juan Generating Station

In this section of the pipeline, the slope from Close-in production to SJGS is downward, so the first phase would not require charge pumps or booster pumps. Dugan Production Corporation (Dugan) and Richardson Operating Company (Richardson) would supply pressurized water to the pipeline to deliver water to SJGS. BHP Billiton and Prax Air would also supply mine water and cooling tower blowdown, respectively. The total delivered flow in Phase 1 would be 548 AF/yr (340 gpm).

Water would be received and stored at SJGS in a 3-day basin. The basin would be sized for Phase 2 flow and would provide two functions. First, it would equalize variations in received produced water chemistry. Second, it would provide water if produced water delivery were interrupted. From the basin, produced water would be pumped to the HERO® system for treatment. Recall that the water delivered from Close-in producers would be exclusively CBM, and as such, would be essentially free of oil and grit. Dugan and Richardson would filter their water before it is placed into the pipeline for conveyance to SJGS. Purge Water (100 gpm) from the SO_2 absorbers

would be blended with produced water for a total flow of 440 gpm (710 AF/yr) before it is fed to the HERO® system.

Figure 7.4



The HERO® system would recover 75.2 percent of the blend of produced water and Purge Water for a total of 534 AF/yr (331 gpm). Reactor clarifier sludge (26.5 tons per day, wet basis) would be used as supplemental limestone feed to the SO_2 absorbers. The reactor clarifier and thickener would be sized to treat the Phase 2 flow. Two options were evaluated in sizing the reactor clarifier:

- Install a 440 gpm reactor clarifier and thickener in Phase 1 and install another 1,100 gpm reactor clarifier and thickener in Phase 2 for a total capacity of 1,540 gpm (53,000 BPD).[4]
- Install a 1,540 gpm reactor clarifier and thickener in Phase 1.

The reactor clarifier is the most difficult piece of treatment equipment to operate (relative to other HERO® equipment) and two reactor clarifiers would unnecessarily complicate the operation. Also, it would be less costly in the long term if only one reactor clarifier and thicker set were installed.

[4] Refer to Deliverable 6, Cost/Benefit Analysis, for equipment sizing criteria. Also, refer to Footnotes 8 and 10.

The HERO® system would generate 106 gpm of wastewater. The evaporation ponds currently have enough capacity to handle 100 gpm of wastewater in this configuration. Therefore, to avoid the capital investment of refurbishing BC 3 in Phase 1, PNM has elected to install ten additional acres of evaporation ponds to handle the 6 gpm of excess water[5].

The treated water could be used for SO_2 absorber, ash system or cooling tower make-up (preferably in this order of use). As discussed in Deliverable 5, Treated Produced Water Compatibility Assessment, using the treated water for absorber make-up requires minimal expense[6].

7.5 Phase 2 Implementation

In Phase 2, the 14-inch pipeline[7] would be extended to its full length of 28.5 miles to treat an average life-of-project flow of 1,790 AF/yr (1,105 gpm)[8] of Close-in, Tri-City and Fairway produced water, water from Prax Air and BHP Billiton, and absorber Purge Water. Refer again to Figure 7.2 for a schematic of the entire pipeline and gathering system.

BR would install satellite collection stations along the Hart Canyon Line and CO_2 Gas Line. PNM would build the Collection Center in Bloomfield to receive and treat[9] produced water delivered by BR. The pipeline extension would meet the Phase 1 line in the Kirtland area. The pipeline extension would have charge pumps and a booster station to handle an increase in elevation and line losses. Gathered water would be blended with 100 gpm of absorber Purge Water at SJGS.

The HERO® system would be expanded from 440 gpm to 1,550 gpm[10] to accommodate the additional flow from the Tri-City and Fairway areas. This would be accomplished by adding additional media filter vessels, WAC vessels and additional RO modules. The increased wastewater stream generated by the HERO® system would require the refurbishment of BC 3. The HERO®/BC 3 configuration would recover 95.3 percent of the water treated for an average life-of-project total of 1,706 AF/yr (1,053 gpm). BC 3 would generate 45 gpm of wastewater, however, no additional evaporation ponds would

[5] Based on the expected evaporation rate, only 3 acres would be required for additional evaporation pond capacity. The plant determined that a 10-acre pond is the minimum size for a cost effective design. Also, the pond would provide capacity for occasional/unplanned plant wastewater.

[6] Using the treated water for the ash system does not require any additional expense, however, the ash system has a relatively small water demand.

[7] The pipeline would be capable of carrying 60,000 BPD (1,800 gpm) of water. In the event that more produced water became available, PNM wanted to be able to have additional pipeline capacity.

[8] Based on 75 to 85 percent recovery of the produced water resource, 6 percent compound declination of the resource and a project life of 20 years. A mid-range recovery of 80 percent was selected for this analysis.

[9] Treatment at the Collection Center in Bloomfield would consist of gravity separation, gas flotation and walnut shell filtration to remove oil and grit. Refer to Section 3.5 and Figure 3.10 in Deliverable 3, Treatment and Disposal Analysis, for more detail.

[10] The HERO® system is sized to treat 53,000 BPD (1,550 gpm), which is the maximum predicted flow (plus a 10 percent capacity cushion) of the produced water resource assuming 85 percent recovery at 6 percent compound declination.

be required. Reactor clarifier sludge (78.9 tons per day, wet basis) would be used as supplemental limestone feed to the SO_2 absorbers.

As in Phase 1, the treated water could be used for SO_2 absorber, ash system or cooling tower make-up.

7.6 Environmental Issues

There are a number of regulatory agencies that must be engaged and permits that must be obtained to build and operate the produced water gathering, conveyance and treatments system. This section of the deliverable addresses the major components of the project and the environmental permits and activities required to implement each phase. Project components that must be addressed by PNM are the pipeline, the treatment plant at SJGS and the Collection Center in Bloomfield. The discussion is purposefully general because of the complexity of the permitting effort and the uncertainties associated with eventual permitting strategies. Environmental issues that must be addressed by the participating oil and gas producers are not included in this analysis.

7.6.1 Phase 1 Environmental Issues

Pipeline

An environmental assessment (EA) must be conducted to determine if any impacts would be created by building and operating the Phase 1 portion of pipeline (10.8 miles), e.g. disturbed habitat during construction or operation of the pipeline. Also, because of the possibility of finding Native-American artifacts, archeological surveys and mitigation plans must be included in the pipeline design. The Bureau of Land Management (BLM) would likely be the lead agency in this effort because a significant portion of the pipeline passes over federal lands. OCD would review the pipeline design, require integrity testing before start-up, and require operating and spill contingency plans.

Phase 1 Treatment Plant

The produced water treatment plant at SJGS would be treated like a storage/disposal facility by ODC[11] and a permit would have to be obtained to build and operate it. As part of the permit application, PNM would have to provide site topographic, geologic and hydrologic information, plant design information, plans for waste handling and spills, etc.

BTEX[12] would be released to the air (likely <0.1 pound per day) from the HERO® system and reuse in the SO_2 absorbers, ash system or cooling towers. BTEX emissions would be low, because produced water in Phase 1 would be generated entirely by CBM production. NMED would be notified of the emissions at the outset of the project, however at these levels, it likely would not require a modification to the plant air permit.

[11] OCD would likely consider the treatment plant similar to a salt water disposal (SWD) facility, where water is stored, treated and disposed of.

[12] BTEX is the sum of the concentrations of benzene, toluene, ethyl benzene and xylene. BTEX is commonly found in conventionally produced water and at trace levels in CBM water. Refer to Deliverable 3, Treatment & Disposal Analysis, Section 3.4.7 for more details.

The plant wastewater permit would have to be modified. Additional wastewater would be generated from HERO® system reject and would be sent to the existing and new plant evaporation ponds for disposal.

Phase 1 environmental permit activity could take up to six months to complete.

7.6.2 Phase 2 Environmental Issues

Pipeline Completion

An EA would be conducted to determine if any environmental impacts would be created by completing the pipeline. Archeological surveys would again be included in the pipeline design. BLM could be the lead agency, however, this leg of the pipeline passes over much more private property and city and state lands than the Phase 1 leg. OCD would review the pipeline completion design, require integrity testing of the extension before start-up and require updates to the operating and spill contingency plans.

Collection Center in Bloomfield

The Collection Center in Bloomfield would be treated like a storage/disposal facility by ODC and a permit would be obtained to build and operate the center. Like the produced water treatment plant at SJGS, PNM would have to provide site and design information and operating plans for the center. An air permit would have to be obtained from NMED for potential BTEX emissions – up to 25 to 30 pounds per day of BTEX could be generated at the center. No wastewater would be generated at the Collection Center. Unrecoverable produced water and waste products (e.g., grit) would be transported to existing licensed disposal operations. Recovered oil would be reclaimed at the Giant Refinery in Bloomfield.

Treatment Plant Expansion

The permit for the produced water treatment plant would be modified to reflect its increased capacity (OCD lead). Both air and wastewater permits would have to be modified to include emissions from produced water treatment (NMED lead). Air emissions could be significantly different with higher levels of BTEX in the delivered produced water (up to 25 to 50 pounds per day). BTEX might also meet the threshold limits to require reporting in the annual Toxics Reporting Inventory (TRI) for SJGS. Wastewater, which would consist of brine from BC 3, would be sent to the evaporation ponds.

Phase 2 environmental permit activity could take six to nine months to complete.

7.7 Capital Expenditure

By developing the project in two phases, PNM could spread capital investment over a period of 3 to 5 years. However, as discussed previously, phasing the project would require a 10-acre evaporation pond to handle excess wastewater in Phase 1. PNM also has decided to use 25 percent contingency for the first phase of the project to cover uncertainties that might arise in a novel reuse project. The evaporation pond and additional contingency would increase the total cost of the project by $3,010,000. Refer to Table 7.1 for a summary of costs by phase.

Table 7.1
Capital Expenditure by Project Phase
PNM – Produced Water Project – SJGS

Equipment Description	Phase 1	Phase 2	Total
Bloomfield Collection Center	$0	$5,200,000	$5,200,000
14-inch Pipeline	$2,940,000	$9,960,000	$12,900,000
Receiving & Transfer Equipment (1)	$1,080,000	$420,000	$1,500,000
HERO System	$3,500,000	$3,760,000	$7,260,000
Refurbish BC 3	$0	$2,970,000	$2,970,000
10-Acre Evaporation Pond	$1,710,000	$0	$1,710,000
Subtotal	$9,230,000	$22,310,000	$31,540,000
Contingency (2)	$2,310,000	$3,350,000	$5,660,000
NMGRT (3)	$570,000	$1,370,000	$1,940,000
PNM G&A (4)	$510,000	$1,230,000	$1,740,000
Total Phased Project Cost	$12,620,000	$28,260,000	$40,880,000
Non-Phased Project Capital Cost (5)			$37,870,000
Additional Project Expenditure			$3,010,000

Notes.....

1. Includes Receiving Basin, produced water transfer pumps and treated water tank, transfer pumps and transfer line.
2. PNM elected to use 25 percent contingency for Phase 1 of the project to cover uncertainties. 15 percent contingency is used for Phase 2.
3. New Mexico gross receipts tax assessed at 6.125%.
4. PNM general and administrative expenses assessed at 5.5 percent.
5. Refer to Deliverable 6, Cost/Benefit Analysis, Section 6.3.

7.8 Summary

PNM is evaluating the development of the produced water project in two phases to spread capital expenditure over a period of 3 to 5 years. The total recovered water after treatment would be 534 AF/yr for Phase 1 and 1,700 AF/yr for Phases 1 and 2.

Phase 1 would consist of the following elements:

- 10.8-mile pipeline to gather and convey water from CBM producers in the Kirtland area, BHP Billiton (mine water) and Prax Air (cooling tower blowdown)
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Phase 2 would consist of the following elements:

- Satellite collection stations (BR's scope of work) to gather water north of Aztec via their Hart Canyon Line and CO_2 Gas Line
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- Expand the HERO® system by adding additional media filter, WAC and RO capacity
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As a result of a bill signed into law March 2004, SJGS could treat and utilize produced water for cooling tower make-up, scrubber make-up, ash wetting, etc. OCD jurisdiction of produced water would end at the treatment system at SJGS. Air and wastewater emissions from the treatment plant would be regulated by the New Mexico Environment Department (NMED).

In Phase 1, an EA must be conducted to determine if any impacts would be created by building and operating the initial portion of pipeline. The Bureau of Land Management (BLM) would likely be the lead agency in this effort because a significant portion of the pipeline passes over federal lands. OCD would review the pipeline design, require integrity testing before start-up, and require operating and spill contingency plans.

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In Phase 2, an EA would be conducted to determine if any environmental impacts would be created by completing the pipeline. BLM could be the lead agency; however, this leg of the pipeline passes over much more private property and city and state lands than the Phase 1 leg. OCD would review the pipeline completion design, require integrity testing of the extension before start-up and require updates to the operating and spill contingency plans.

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The permit for the produced water treatment plant would be modified to reflect its increased capacity (OCD lead). Both air and wastewater permits would have to be modified to include emissions from produced water treatment (NMED lead). BTEX might also meet the threshold requirement to require reporting in the annual Toxics Reporting Inventory (TRI) for SJGS. Phase 2 environmental permit activity could take six to nine months to complete.

By developing the project in two phases, PNM could spread capital investment over a period of 3 to 5 years. The 10-acre evaporation pond and additional Phase 1 contingency would increase the total cost of the project by $3,010,000 – from $37,870,000 to $40,880,000.